Morse (E.S.)

ADDRESS

OF

EDWARD S. MORSE,

PRESIDENT

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American Association for the Advancement of Science.

DELIVERED AT THE

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E. S. MORSE,

THE RETIRING PRESIDENT OF THE ASSOCIATION.

Ladies and Gentlemen of the American Association for the Advancement of Science:—

Eleven years ago I had the honor of reading before this association an address in which an attempt was made to show what American zoölogists had done for evolution. My reasons for selecting this subject were, first, that no general review of this nature had been made; and, second, that many of the oft-repeated examples in support of the Derivative theory were from European sources and did not carry the weight of equally important facts, the records of which were concealed in our own scientific journals. Darwin was pleased to write to me that most of the facts I had mentioned were familiar to him, but to use his own words he was amazed at their number and importance when brought together in this manner. The encouragement of his recognition has led me to select a continuation of this theme as a subject for the customary presidential address, a task which is at best a thankless if not a profitless one. Had I faintly realized, however, the increasing number and importance of the contributions made by our students on this subject, I should certainly have chosen a different theme.

Incomplete as is this record of ten years work I am compelled to present it. In the Buffalo address two marked periods in the work of the zoölogists in this country are recognized: the one period embracing the work of the topographers, the field surveyors in the science; the other period dating from the advent of Agassiz with the wonderful impulse he imparted to the study by his enthusiasm and devotion. A third period in American zoölogical science, and by far the most important awakening, dates from the

publication of Darwin's "Origin of Species." Its effect on zoölogical literature was striking. The papers were first tinged with the new doctrine, then saturated, and now, without reference to the theory, Derivation is taken for granted.

As zoölogists we are indebted to Darwin for the wide-spread public interest in our work. Before Darwin the importance of our special studies was far outweighed by the practical value placed upon science in the application of which an immediate material gain was assured. Chemistry, physics, geology were important only because a practical application of these sciences was capable of showing an immediate material return.

Agassiz, in his appeal to the state for appropriations for the great Museum at Cambridge, insisted that there were higher dividends than those of money to be looked for in endowments for zoölogical museums and these were intellectual dividends. While the force of this appeal will always remain true, the transcendent importance of the naturalist's studies from the standpoint of Darwin is widely recognized. Man now becomes an object of rigid scientific scrutiny from the new position which has shed such a flood of light upon the animals below him. His habits, behavior, the physical influences of his environment and their effects upon him, transmission of peculiarities through the laws of heredity,—all these factors are directly implicated in the burning questions and problems which agitate him to-day. Questions of labor, temperance, prison reform, distribution of charities, religious agitations are questions immediately concerning the mammal man and are now to be seriously studied from the solid standpoint of observation and experiment and not from the emotional and often incongruous attitude of the church. To a naturalist, it may seem well nigh profitless to discuss the question of evolution since the battle has been won, and if there be any discussion it is as to the relative merits and force of the various factors involved. The public, however, are greatly interested in the matter as may be seen by a renewal of the fight in the English reviews, and the agitation is still kept up by well-meaning, though ignorant advisers, who insist that science has not yet accepted the doctrine; and great church organizations meet to condemn and expel their teachers of science from certain schools of learning because their teachings are imbued with the heresy.

Dr. Asa Gray,[1] in his discriminating biographical memoir of

Darwin, says in regard to the "Doctrine of Descent" "it is an advance from which it is evidently impossible to recede. As has been said of the theory of the Conservation of Energy, so of this: 'The proof of this great generalization, like that of all other generalizations, lies mainly in the fact that the evidence in its favor is continually augmenting, while that against it is continually diminishing, as the progress of science reveals to us more and more the workings of the universe.'" Let us examine then the evidences, trivial as well as important, that have been recorded by American zoölogists within the past ten years in support of the Derivative theory.

Without further apology for the very imperfect character of this survey, let me at once begin by calling attention first to the testimony regarding the variation in habits and evidences of reasoning power in animals. The establishment of individual variation in mental powers, change in habits, etc., lies at the foundation of Darwinism as furnishing material for selective action. There is no group of animals which exceeds the birds in varied and suggestive material for the evolutionist. It is a significant fact that the birds, which appeared to Cuvier and his contemporaries a closed type, a group that seemed to fulfil the ideal conception of a class archetype, as compared with other groups which had their open as well as obscure relationships, should be of all groups the one that first yielded its exclusive characteristics. In fact there is no group in which the barriers have been so completely demolished as in this apparently distinct and isolated class. An attentive and patient study of the birds has established almost every point defined by Darwin in his theory of natural selection. One has only to recall the marked reptilian affinities as shown in their embryological and paleontological history. Besides all these structural relationships the birds possess as a group remarkable and striking illustrations of variation in color, size, marking, nesting, albinism, melanism, moulting, migration, song, geographical variation, sexual selection, secondary sexual characters, protective coloring; and in their habits show surprising mechanical cunning and ingenuity, curious and inexplicable freaks, parental affection, hybridity,—indeed the student need go no farther than the birds to establish every principle of the Derivative theory.

The many observations on the nesting habits of birds would form a curious chapter as illustrating the individual peculiarities of these creatures.

Dr. A. S. Packard[2] records the fact, as related to him by Mr. Wyatt, of wild geese nesting in large cotton-wood trees on Snake river, west of the Rocky mountains, and Doctor Coues in his "Birds of the Northwest" says wild geese "nest in various parts of the Upper Missouri and Yellowstone regions in trees." Mr. H. W. Turner[3] observes a robin nesting on the ground. The late Dr. T. M. Brewer[4] points out some very curious "Variations in the Nests of the same Species of Birds." He not only observes individual variation in nest structure, but shows that in different regions of the country birds of the same species build different kinds of nests, and in reflecting on these peculiarities he is led to say "If we cannot understand what it can be that stimulates an *Empidonax* in Staten island to build a pensile nest, while its fellow in Indiana builds one like a deep cup and surrounded with thorns, and another group in Pennsylvania put theirs on an exposed tree top, and so flat that the eggs seem liable to roll out, we must see that some cause, hidden to us, is gradually effecting changes that sooner or later may become universal in the species, though which it is to be we may not be able to imagine."

Mr. J. A. Allen,[5] in writing on the inadequate theory of birds' nests, shows grave and important exceptions to Wallace's theory, though he subscribes heartily to his philosophy of birds' nests. He expresses surprise that closely allied species of birds should oftentimes build divers kinds of nests, overlooking the fact that even closely allied varieties of man build entirely unlike houses.

Mr. F. H. Knowlton[6] records a cliff swallow appropriating, for the construction of its own nest, pellets of mud which were being brought by another swallow. Also the curious fact that a number of swallows were observed busily engaged in sealing up a nest in which one of their comrades lay dead. Among the curious traits of birds, Mr. H. B. Bailey[7] communicates some new ones observed in the red-headed woodpecker by Mr. Agersborg of Dakota territory. This gentleman had observed one of these birds wedging grasshoppers in a large crack of an old oak post. Nearly a hundred were stored away in this manner, the bird afterwards feeding at leisure on the supply. This parallels the habit of the California woodpecker storing acorns in holes in the tree and subsequently feeding on the fully developed larvæ within the seed.

Mr. O. P. Hay,[8] in a late number of the Auk, has an interesting paper on the red-headed woodpecker as a hoarder, showing that the bird makes accumulations of beech nuts, pounding them be-

tween the shingles of a roof, wedging them into crevices and storing them in cavities in trees.

The plausible suggestion made by Darwin as to the agency of aquatic birds in the wide dispersal of fresh-water mollusks, was singularly confirmed several years after by Mr. Arthur F. Gray shooting a duck which had clinging to one of its toes a fresh-water mussel. Dr. J. W. Fewkes[9] has recently recorded the shooting of a duck in Sebec, Maine, which was in like manner transporting a fresh-water mussel. The same bird had been observed several days before with this curious companion clinging to its foot, and had the duck been migrating at the time it might have transported the mussel many hundreds of miles. In this connection it would be an interesting inquiry as to how far the similarity observed in north temperate and circumpolar animals is due to the annual migration of birds north and south.

Mr. William Brewster [10] notes some interesting features in the habits of a young Kittiwake gull of the St. Lawrence. He brought home a young one, its mate having died of thirst, the other one surviving through the accidental discovery that the bird drank only salt water! Both the birds obstinately refused to drink fresh water. Observations on this bird by Prof. A. Hyatt showed how slowly and timidly it acquired the art of swimming and flying. The bird when first forced to fly was thrown into the air and to the surprise of Professor Hyatt flew with great rapidity and precision, circling about the house and through the apple trees, and, finally, flew near him several times in the greatest agitation till he caught the bird which was completely exhausted. For a long time the bird went through this manœuvre, showing that while he knew how to fly it could not alight, though it finally acquired this faculty. Prof. L. A. Lee[11] records a remarkable attack made on him by a marsh hawk, and Mr. Abbott M. Frazer[12] tells of a tame crow deliberately standing on an ant hill and permitting the ants to remove the parasites from its feathers. In this connection a paper by Mr. Joseph F. James [13] should be read in which he shows by a number of arguments that animals not only present a reasoning faculty, but that this faculty has been the result of slow evolution.

Mr. Xenos Clark,[13a] in an exceedingly interesting article on the music of animals and particularly the music of birds, concludes by saying there is "a theory for the origin of melody, whether

human or extra-human, which, besides the usual basis of physiological acoustics, employs the law of modified, inherited, selected and adapted structure, *i. e.*, the law of evolution."

Mr. Ruthven Deane [14] records cases of albinism and melanism in a great many families of birds, and Mr. N. C. Brown [15] shows the variable abundance of birds at the same locality in different years. In this connection it will be of interest to read Dr. L. P. Gratacap's [16] paper entitled "Zoic Maxima, or Periods of Numerical Variations in Animals."

The behavior of wild birds when kept in confinement and the attempts made in domesticating them have always furnished an interesting field for study. The curious freaks and impulses which they often betray, the changes they show under the new conditions, indicate in some measure the plasticity of their organization.

Hon. John D. Caton,[17] in an interesting paper on "Unnatural Attachments among Animals," records a curious fondness shown by a crane for a number of pigs, and in another paper on the "Wild Turkey and its Domestication"[18] this writer has made some valuable records of the successive changes which take place in the bird during this process; changes in color during which the more conspicuous features of protective coloring are lost; changes in habit in which is seen the undoing or relaxing of those features which indicate constant vigilance, from carrying itself in a semi-erect attitude, perching on the tallest trees, covering up the eggs carefully with leaves when off the nest, etc., to moving in an horizontal attitude, perching near the ground, covering the eggs but slightly, or carelessly, etc., and losing that wildness which characterizes the bird in its wild state. At the breeding season, however, the females became wild again, but this was a feature too deeply implanted to show modification in the time allotted to Mr. Caton's experiment. The same writer[19] has also observed in the Hawaiian Islands the effects of reversion to a wild state of different kinds of domestic animals which have from time to time been carried there. Among other animals he was fortunate enough to observe the undoing stages in the domestic turkey and the assumption of those features which characterize the wild bird.

A great many facts illustrating the plainest features of natural selection, protective coloring, mimicry, etc., have been recorded in our journals from time to time. A brief allusion may be made to a few of these.

Prof. Samuel F. Clarke [20] notices a pronounced case of natural selection,— a case which must often occur in nature. He kept in large glass jars masses of eggs of Amblystoma. As soon as these eggs began to hatch he found it difficult to provide the young with suitable food, and yet they seemed to thrive. On examination many of them were seen to be engaged in nibbling the branchia of others, and as they increased in size they were seen to swallow the weaker individuals bodily and hence grow with increased rapidity. "Here then," he says, "was a very interesting case of natural selection by survival of the fittest. All the weaker individuals being destroyed and actually aiding the stronger ones by serving them as food until they could pass through their changes and escape to other regions where food was more abundant." Prof. B. G. Wilder has recorded a similar condition of things in a species of spider where the young spiders within the case enclosing the eggs were feeding on the weaker ones. Prof. Henry L. Osborn [21] observes a curious case of mimicry at Beaufort in the coloring of a species of Ovulum which frequents a species of Leptogorgia. The Ovulum was yellow in color on the yellow variety of this sea fan, and purple when living on the purple variety. Dr. R. E. C. Stearns [22] has made some interesting notes on protective coloring in Phrynosomæ. Having collected these horned lizards (or toads as they are commonly called) in Central California, he has noticed that if the ground region they frequent is yellowish, the lizards are without exception of that color; if ashen grey, then that color is simulated, and this, without exception. Further than this he is "led to believe that a sufficient number of living specimens will show a similar protective factor, in degree of development of the scale imbrications, tubercles so called, and horns — or, in brief, in the sculpture aspect as related to the surface texture of the ground which forms the local habitat of these forms." Dr. A. S. Packard [23] has observed the partiality of white butterflies for white flowers. He notices the European cabbage butterfly, which is white, go directly to the white aster and rarely visit the golden rod, while the yellow sulphur butterfly visits the yellow flowers of the golden rod oftener than those of the aster. The same author [24] also observed a harmless Egerian moth which deceived the sharp eye of a trained entomologist by its resemblance to a wasp, and asks why a bird may not be equally deceived. Miss Sarah P. Monks [25] observed a case of mimetic coloring in tadpoles, their tails precisely resembling the leaves of an aquatic plant, Ludovidgia.

Miss Mary E. Murtfeldt [6] having noticed that the butterfly, *Pyrameis huntari*, always deposited its eggs on the plant Ambrosia, she was surprised to find a number of larvæ of this butterfly on Artemisia. The customary plant being rare in the immediate vicinity, the butterfly had been misled by the surface resemblance of the white cottony leaves of the Artemisia to those of the accustomed food plant. In this case the larvæ all died.

An unquestionable fact has been finally established by recent methods of observation on the habits of insects and other animals, and that is that individuals of the same species vary in intelligence; that they are not automata; that they are not impelled by a blind instinct to perform certain acts with unerring accuracy, but on the contrary that they vary and often greatly vary in their skills to provide for their young, in their skill to secure sufficient food, in their wit to avoid danger,—in other words, they make blunders and mistakes and involve their progeny and even their colony in ruin. This individual variation in intelligence is brought out very clearly by a patient series of observations made by Drs. G. W. and E. G. Peckham [7] on the special senses of wasps. They not only repeated many of the experiments of Sir John Lubbock but many new and ingenious experiments were devised. Their studies were for the purpose of investigating the mental power, sense of locating, color, direction, memory, emotion, power of communication, general intelligence, etc. An interesting result of their painstaking work was the determination of individual differences as to the faculty of memory and power of distinguishing color and direction. This kind of study of the habits of insects has brought to light features of the most surprising character. The remarkable studies of Sir John Lubbock, Dr. Moggridge and others in Europe have been paralleled in this country not only by the observations above quoted, but notably by the labors of Rev. H. C. McCook [8] in his studies of the American ants and spiders. In various papers published in the Proceedings of the Philadelphia Academy of Natural Sciences and in the American Naturalist, he has shown many extraordinary and curious features in the life histories of these animals. The great variety and extent of his work must be my excuse for not referring to it in detail.

Prof. G. F. Atkinson,[9] in studying a new species of trap-door spider, confirms the observations of others as to the creature deliberately attaching fragments of moss to the lid of the nest to cover or conceal its position. Dr. Thomas Meehan [10] mentions a

hornet that was gifted with great intelligence. He saw this insect struggling with a large locust in unsuccessful attempts to fly away with it. After several fruitless efforts to fly up from the ground with his victim he finally dragged it fully thirty feet to a tree, to the top of which he laboriously ascended, still clinging to his burden, and having attained this elevated position he flew off in a horizontal direction with the locust. Dr. Meehan truly says "There was more than instinct in this act, there was reasoning on certain facts and judgment accordingly and the insect's judgment had proved correct."

A curious case of circumspection in ants is recorded by Dr. Joseph Leidy.[31] In an empty house he observed some ants feeding on crumbs of bread left by the workman. He at once placed pieces of bread in the different rooms in the house only to find them the next day covered with ants, which he destroyed by causing them to fall into a dish of turpentine. After a few days the ants no longer visited the bread and he supposed they had been exterminated. A few days after, however, he observed a number of ants in the attic feeding on the body of a dead fly. He immediately got a lot of grasshoppers and distributed their bodies in all the rooms, only to find that they were soon covered with ants, which he destroyed as before. This treat continued attractive for a few days only, when the ants abandoned the food. In brief he tried meat, cake and various other articles in turn; the ants for a while frequenting these snares only to learn the danger involved and finally avoided them.

The gradual dispersion of species in recent times is of great interest, and careful records should be made of the facts as observed and a collection of large numbers of individuals made, in order to compare them with specimens of the same species in future years, to ascertain the variation which may have taken place and the tendency of that variation. A number of observations have been published within the last ten years showing new areas of distribution. *Littorina litorea*, which has been creeping along the coast since 1869, as recorded by Gray, Verrill and others, has now reached the southern side of Long Island Sound as observed by Mr. Henry Prime.[32] *Lioplax sub-carinata*, an Ohio river species, has been found in the Hudson river at Catskill landing. *Limax maximus*, first found at Newport, R. I., by Mr. Powel, has since been found at Cambridge, Mass., by Professor Hyatt. *Bythinia*

testaceum, first recorded from Oswego, N. Y., by Rev. W. M. Beauchamp,[16] is reported as having been found at Burlington, Vt., by G. H. Hudson. In the Mohawk river is a thriving community of this species, the first having been placed there by Dr. James Lewis.

Dr. R. E. C. Stearns,[17] in commenting on the occurrence of *Mya arenaria* in San Francisco Bay, states that the first record of the species in California was made by Dr. Newcomb in 1874. Within a few years it has increased in great numbers, furnishing a new food supply for the people. The evidence that it is a recent introduction is seen in the fact that so large and conspicuous a species could not have escaped the eye of the collector. No trace of it has ever been found in the numerous shell heaps of California, though it is found on the Asiatic coast, from Kamtchatka to the southernmost limits of Japan. Dr. Stearns believes it to have been imported with the oysters transplanted from the Atlantic coast. From large numbers of the shells that I measured, the low index would show that it came from some southern point on the Atlantic coast.

The delicate balance of conditions between organisms, whether it be between individuals of the same species or between widely separated groups, is an important feature in the question of survival. Prof. S. A. Forbes,[18] in a thoughtful study of certain species of Entomostraca in Lake Michigan and the surrounding waters, calls attention to the important part played by these minute crustaceans, showing how they furnish almost the entire food for young fishes, larger crustaceans and even insect larvæ. He writes: "Mollusks, one would say, could afford to be indifferent to them, since they neither eat them nor are eaten by them, nor seem to come in contact with them anywhere, through any of their habits or necessities. But for this very reason these two classes afford an excellent illustration of the stringent system of reactions by which an assemblage of even the most diverse and seemingly independent organisms is held together. . . . . If there were no entomostraca for young fishes to eat, there would be very few fishes indeed to feed upon molluscs, and that class would flourish almost without restraint; while, on the other hand, if there were no molluscs for the support of adult fishes, entomostraca would be relieved from a considerable part of the drain upon their numbers, and would multiply accordingly." He is much struck with the fact that in the

larger bodies of water, the species of entomostraca show an inferior development in numbers, size and robustness, and in reproductive power. Their smaller number and size are doubtless due to the relative scarcity of food. "The difference of reproductive energy, as shown by the much smaller egg-masses borne by the lacustrine species, depends upon the vastly greater destruction to which the paludinal crustacea are subjected Many of the latter occupy waters liable to be exhausted by drought, with a consequent enormous waste of entomostracan life. The opportunity for reproduction is here greatly limited — in some situations to early spring alone — and the chances for destruction of the summer eggs in the dry and often dusty soil are so numerous that only the most prolific species can maintain themselves under such conditions.

"Further, the marshes and shallower lakes are the favorite breeding grounds of fishes, which migrate to them in spawning time, if possible, and it is from the entomostraca found here that most young fishes get their earliest food supplies—a danger from which the deep-water species are measurably free. Not only is a high reproductive power therefore rendered unnecessary among the latter by their freedom from many dangers to which the shallow-water species are exposed, but in view of the relatively small amount of food available for them, a high rate of multiplication would be a positive injury, and could result only in wholesale starvation."

The effect of birds on insect life has engaged the attention of the same author.[36] His inquiry was to ascertain whether birds originated any oscillations in the numerical proportion of insects upon which they feed. Many interesting facts are given which space forbids quoting.

A number of contributions have been made on the influence of environment and on geographical variation, to some of which reference must be made. Prof. Alpheus Hyatt[37] bears unequivocal testimony to the Derivative theory and recognizes clearly the influence of external surroundings in a memoir on the cephalopods, when in stating the law of organic equivalence he says: "The action of physical changes takes effect upon the irritable organism, which necessarily responds to external stimulants by an internal reaction or effort. This action from within upon the parts of the organism modifies their hereditary forms by the production of new growths or changes which are, therefore, adapted to the conditions of the habitat or the physical agents and forces from which they directly

or indirectly originate;" or, slightly changing this interpretation in accordance with the same facts, each individual is more or less susceptible to the action of physical influences and those which respond most quickly to these influences come more promptly in harmony with their environment which is natural selection, pure and simple.

Mr. Charles Morris,[28] in a series of papers on "Organic Physics" and the "Polar Organization of Animals," presents many new and suggestive thoughts on the physico-chemical action in life and development. He concludes that "there are inherent in the germ energies and tendencies, chemical, molecular, or whatever we choose to call them, adapted to the complete unfoldment of the typical form; but, as appears evident, their operation can be checked by influences from external nature. There is a struggle between these contact influences and the innate organic tendencies."

Under geographical variation many interesting facts have been added since Professor Baird, Dr. Allen and Mr. Ridgway published their capital discoveries, calling attention to the variations observed in birds and mammals coincident with their latitudinal range. William Bartram, grandnephew of the famous botanist John Bartram, alludes to the effect of climate in modifying species. In speaking of birds he says: "the different soil and situation of the country may have contributed in some measure in forming and establishing the difference in size and qualities betwixt them."

Dr. J. A. Allen[29] shows marked geographical variation among North American mammals in respect to size. He shows that "1. The maximum physical development of the individual is attained when the conditions of environment are most favorable to the life of the species. 2. The largest species of a group [genus, sub-family, or family, as the case may be] are found where the group to which they severally belong reaches its highest development, or where it has what may be termed its centre of distribution. 3. The most typical or most generalized representatives of a group are found also near the centre of distribution, outlying forms being generally more or less aberrant or specialized." In the study of the eggs of birds of the same species, north and south, Dr. Allen shows that in the south the eggs are less in number and smaller in size.[30] Mr. Robert Ridgway[31] calls attention to the geographical variation observed in Dendroica.

The same author,[32] in a discussion of a paper by Salvin in

the Transactions of the Zoölogical Society of London, on the relationships between the birds of Guadalupe and the mainland, refers to the present genesis of species, and points to the increase in size of the bill and feet, the shorter tail and wings and darker colors, as characterizing them.

Dr. E. C. Coues,[43] in his studies regarding geographical variation in color among North American Insectivorous mammals, says: "My studies up to the present go to show a very interesting parallelism with the state of the case I have determined for other small mammals, notably the mice and gophers, and which my friend Mr. Allen has admirably brought out in his studies of the squirrels. In some cases I find almost identical effects of climatic, or other conditions upon the shrews and the mice of particular localities, by which they both acquire the same *facies loci*. Present indications are that the normal variability of the shrews in size, shape and color is not less than has been determined to hold good in various other families of mammals." In this memoir Dr. Coues has verified a curious fact first pointed out by Professor Baird, of the modifications of the premolar dentition which the western species collectively, as compared with the eastern, have undergone; "A striking peculiarity of all the western species, no matter how diverse in other respects, is to have the 'third premolar' decidedly smaller than the 'fourth', while in all the species east of the Rocky Mountains (with one possible exception) the same tooth is as large as, or larger than, the other. Of the fact there is no question; it may be observed in an instant, and is unmistakable. Its significance is another thing. Some of the western species are scarcely distinguishable if at all from their respective eastern analogues, except by this character, and they all show it."

Prof. A. Hyatt[44] finds in sponges geographical variation in color, referring to similar features in birds as recorded by Baird and others.

Prof. David S. Jordan,[45] in a paper on the distribution of fresh-water fishes, presents a concise series of propositions which govern these animals in the United States. They all point to the action and importance of physical conditions as governing distribution. Space will permit only the quoting of the last proposition, which is a summing up of his conclusions: "The distribution of fresh-water fishes is dependent on (*a*) fresh-water communication; on (*b*) character of stream, that is, of water, as to purity,

depth, rapidity, vegetable growth, etc.; on (c) the character of the river bed, as to size, condition of bottom, etc.; on (d) climate, as determined by latitude and by elevation above the sea; and finally on (e) various unknown factors arising from the nature or the past history of the species in question, or from the geological history of the rivers."

Dr. James Lewis[36] has observed a not unlike condition of things in the distribution of the fresh-water mussels of Ohio and Alabama. By a series of tables he calls attention to what he believes is the occurrence of identical and equivalent species in the two systems of drainage and suggests that, owing to the number of variables characterizing the *Unionidæ* they may be identical. This author[37] has also studied the genus *Io* and its habits and notices its variation coincident with latitude and temperature.

Dr. R. E. C. Stearns,[38] in a paper on the circumpolar distribution of certain fresh-water mussels and the identity of certain species, unites many hitherto recognized species of *Lasmona*. Dr. J. G. Cooper,[39] in a study of the fossil and subfossil land shells of the United States, sees the strongest evidence in support of the idea that the older ones are the direct ancestors of certain forms living to-day.

Mr. R. P. Whitfield[40] read a paper before the Boston Society of Natural History, showing changes produced in *Limnæa megasoma* when kept in an aquarium. Having at the outset three specimens, two of them finally died and from the remaining one eggs were produced, presumably unimpregnated. These eggs hatched, and from these the next year came a second generation, which in turn produced a third generation the following year. The animal of *Limnæa* is hermaphrodite. Nevertheless besides diminished size in the shell it was observed that the male parts had disappeared and the liver had become considerably reduced in size. He infers that a dioicous species bred in a short time become monœcious as a result of the new physical conditions of life in the constricted quarters of an aquarium.

An instructive paper by Dr. W. D. Hartman,[41] on the genus *Partula* of the Hawaiian Islands, shows in the most convincing manner the effect of environment in modifying the species. He finds a common occurrence of hybrids among certain forms, the result of the union of proximate species. This hybridization occurring even between arboreal and ground species, Dr. Hartman states "that

gravid females are often washed by heavy rains from a favored position to drier levels, where after a few generations the progeny become depauperated, and so stunted in size as to be mistaken for distinct species." Dr. W. H. Dall,[52] in some general considerations regarding the environment of the deep-sea mollusks as compared with the shallow-water and littoral forms, shows how much the littoral forms have to contend with in the struggle for existence as compared with the deep-sea forms, and the delicate sculpture and extreme fragility of many of the shells occurring in the deeper abysses of the sea are to be explained on the ground of their habitat. Dr. Carl F. Gissler[53] has presented some interesting evidences of the effect of chemico-physical influences in the evolution of the branchipod crustaceans.

The effect of mechanical strains as producing like morphological effects has been treated in a masterly way by Dr. John A. Ryder.[54] He cites the vertebral axes of turtles and extinct armadillos, also the sacra of birds and mammals, and says "These observed coincidences, it is believed, are neither accidental, nor designed by an active cause external to these organisms or their cosmic environment. I would rather believe that the structures, so far as they have been evolved in parallel or similar ways, are the results of like forces conditioning growth and nutrition in definite modes and determinate directions. The manner of incidence of the modifying forces being in all cases determined by the voluntary actions of the organisms, the actions in turn are determined by the degree of intelligence of the animal manifesting them."

In considering the "Laws of Digital Reduction"[55] Doctor Ryder gives a concise presentation of the various groups of animals, showing in each the line of mechanical strain in the extremities and its correlation with the increased development of those digits bearing this strain, and the consequent reduction or atrophy of those digits out of this line. These considerations led him to the following conclusions:

I. "That the mechanical force used in locomotion during the struggle for existence has determined the digits which are now performing the pedal function in such groups as have undergone digital reduction.

II. That where the distribution of mechanical strains has been alike upon all the digits of the manus or pes, or both, they have remained in a state of approximate uniformity of development.

III. It is held that these views are Lamarkian and not Darwinian; that is, that they more especially take cognizance of mechanical force as a mutating factor in evolution, in accordance with the doctrine of the correlation of forces."

Doctor Ryder further says: "It seems a most convincing proof of the doctrine of descent to find man an instance of the same kind of specialization determined by the manner of the distribution of strains as is so often found among the lower groups, such as the lemurs, sloths, jumping mice and even-toed ungulates."

In another memoir[6] Doctor Ryder considers the mechanical motion in forming and modifying teeth. Considering first the simplest form of movement in the mammal's jaw, opening and closing, without fore and aft or lateral movement, he shows the successive changes going on coincident with the more complex movements of the jaw, and that the enamel foldings, ridges, crests, etc., have apparently been modified in conformity with the ways in which the force used in mastication was exerted.

Prof. A. Hyatt,[7] in an exhaustive study of the Planorbis of Steinheim, shows among other things the effect of gravitation in accounting for the form of the mollusk shell, citing examples from all the classes and even drawing examples from other subkingdoms to support his views.

Prof. E. D. Cope,[8] in a memoir on Archæolution, considers the hypothesis of use and effort, the effect of unconsciousness, etc. He attempts to show that consciousness is primitive and a cause of evolution. He sustains his thesis by a series of arguments which, if not beyond my grasp, would be too extensive to present here. I can only repeat the regret I expressed in the Buffalo address; namely, that neither Professor Cope nor Professor Hyatt has yet been induced to present to the public an illustrated and simple outline of their theories. Such a demonstration, I am sure, would be acceptable not only to the public but to many scientific students as well. While these two eminent naturalists believe fully in the Darwinian theory they insist that Darwin's theory is inadequate to explain many of the phenomena and links which they encounter in their studies. Darwin has distinctly said in his first edition of the "Origin of Species," "I am convinced that natural selection has been the main but not the exclusive means of modification;" and in his sixth edition of the same work, in quoting these words, he laments that he is still misunderstood on this point. The theory of coadaptation and reservation of these authors is, if I under-

stand it rightly, a very plain case of natural selection. It was inevitable that those individuals that matured the quickest were better prepared to defend themselves, were quicker in the field, were able to give their offspring an earlier start in the season, were in every way more fitted to survive than those which matured later. It is assumed that this is a law when, to my mind, it seems the simplest result of natural selection. Instead of overriding it, it is only a conspicuous result and proof of it.

A parallel case may be seen in the increase in size of the brain in the vertebrates, and conspicuously in the higher vertebrates, since their first appearance in geological history. The individual brain clearly varies in size and it does not require a great effort to perceive how in the long run the greater brain survives in the complex struggle for existence. Associated with the greater development, parts that were freely used for locomotion before are now compelled to perform additional service, and through the law of use and effort, which all admit as an important factor, organs are modified in structure, the anterior portion of the body assumes a new aspect; and it was on the character of these parts and aspects that Professor Dana was led to formulate his comprehensive and ingenious principle of Cephalization. It is a result and not a cause. And so I believe, though with great deference to Cope and Hyatt, that the laws of acceleration and retardation, exact parallelisms, inexact parallelisms and still more inexact parallelisms, and many other laws and theories advanced by these gentlemen, are not causes but effects, to be explained by the doctrine of natural selection and survival of the fittest.

The connecting links and intermediate forms which the skeptical public so hungrily demand are continually being discovered. Great gaps are being closed up rapidly, but the records of this work being published in the journals of our scientific societies are hidden from the public eye as much as if they had been published in Coptic. So rapidly have these missing links been established that the general zoölogist finds it difficult to keep up with the progress made in this direction. He can hardly realize the completion of so many branches of the genealogical tree.

Professor Cope,[59] who has accomplished so much in this direction, says: "Those who have, during the last ten years, devoted themselves to this study have been rewarded by the discovery of the course of development of many lines of animals, so that it is now

possible to show the kind of changes in structure which have resulted in the species of animals with which we are familiar as living on the surface of the earth at the present time. Not that this continent has given us the parentage of all forms of animal life, or all forms of animals with skeletons, or vertebræ, but it has given us many of them. To take the vertebrata, we have obtained the long-since extinct ancestor of the very lowest vertebrates. Then we have discovered the ancestor of the true fishes. We have the ancestor of all the reptiles, of the birds, and of the mammals. If we consider the mammals, or milk-givers, separately, we have traced up a great many lines to their points of departure from very primitive things. Thus we have obtained the genealogical trees of the deer, the camels, the musk, the horse, the tapir, and the rhinoceros, of the cats and dogs, of the lemurs and monkeys, and have important evidence as to the origin of man."

In 1874 he predicted that the ancestor of all the mammals would be a five-toed, flat-footed walker with tuberculous molar teeth, or in exact language a pentadactyle, plantigrade bunodont. Seven years after he obtained evidence that such a type of mammals abounded in North America during the early Eocene Tertiary period. Prof. Cope,[36] in his phylogeny of the camels, shows a remarkable parallel to that of the horse, both forms appearing in the lower Eocene. Mr. Eugene N. S. Ringueberg[37] believes he has found in a thin layer of limestone at Gasport, N. Y., a deposit in which a number of forms of Brachiopoda seem to present the intermediate stages between certain brachiopods common to the Clinton and the group of rocks immediately above. While the majority of species in this deposit belong to the Niagara, there are among the fossils met with, three species of brachiopods which were supposed to have passed out of existence with the Clinton. He finds in this bed thirty-two forms peculiar to the Niagara, eleven common to Niagara and Clinton, three belonging to the Clinton and two characteristic forms of the transition group. Many of these show intermediate characters.

Prof. H. S. Williams,[38] in his paleontological studies of the life history of *Spirifer lævis*, in which he traces the ancestral line of this creature, says: "Whatever theoretical description we may give to species, here are, in the first place, an abundance of individual organisms whose remains are found in the upper Silurian rocks of Europe, Great Britain and America, presenting a few clearly marked distinctive characters, which are found variously developed in the

individual forms, but so grading in the various varieties as to cause careful naturalists to associate them as varieties of a single species."

Dr. C. A. White,[63] in his comparisons of the fresh-water mussels and associated mollusks of the Mesozoic and Cenozoic periods with living species, expresses his belief that the present Unios of North America, particularly those forms allied to *Unio clavus*, have come down in an unbroken line from the Jurassic and possibly from earlier times. He shows that thus far all the fossil Unios have been obtained from lacustrine deposits, none of these beds being distinctly fluviatile. He furthermore calls attention to the fact that "these lacustrine formations are of very great extent in western North America, and, without doubt, the lakes in which they were deposited were caused by encircling bands of rising land during the elevation of the continent. These great land-locked waters were at first brackish, but finally became, and for a long time remained, fresh, continuing so until their final desiccation." From this commingling of salt and fresh water he justly assumes that many modifications arose in the forms of Unios subjected to these influences and hence has resulted a variety of forms which have gone on continually widening to the present day.

Prof. A. G. Wetherby,[64] in a paper on the geographical distribution of certain fresh-water mollusca and the possible cause of their variation, shows the paucity of forms of Unionidæ on the Pacific and Atlantic coasts as compared to the richness and profusion of those forms in the central portion of the continents. He remarks also on the absence of the family Strepotomidæ, east of the Alleghanies. He assumes that the first fresh-water forms were lacustrine. He points out the well-known geological fact of large inland enclosures and their subsequent drainage, and shows the vicissitudes which must have been encountered by species in the variety of physical conditions implied by these changes. In this connection I may be permitted to call attention to the fact that at a meeting of this Association, at Hartford, in 1874, I made a communication on the origin of the North American Unionidæ in which I urged some of the points made by Dr. White and Professor Wetherby.*

*The following is a brief abstract which was published in the Hartford Courant August, 1874. "Mr. Morse in explaining the origin of the North American Unionidæ did not pretend to point out the absolute line of descent in these forms, but wished to call attention to some curious features in the possible derivation of the fresh-water families of Mollusks from cognate genera living in salt water. It is observed, first, that the

Dr. Thomas H. Streets,[7] in studying the immature plumage of the North American shrikes, was much struck with the close resemblance between the plumage of the young of *Sula cyanops* and the adult plumage of another species. Recalling a generalization made by Darwin that "when the young differs in color from the adult, and the colors of the former are not, as far as we can see, of any special service, they may generally be attributed, like various embryological structures, to the retention by the young of the characters of an early progenitor." He then shows the gradation between the several species of shrikes from this standpoint and traces their descent from a common ancestor.

Prof. S. A. Forbes,[8] in a study of the "Blind Cave Fish and their Allies," is led to review the conclusions reached by Prof. F. W. Putnam in his interesting papers on the subject. Professor Putnam brought forth a number of arguments which seemed to him to militate against the views urged by evolutionists that their peculiar characters were adaptive and the result of their cave life. He was led to the conclusion that the absence of light had not brought about the atrophy of the eyes, the development of special sense organs, and the bleaching of the skin. In referring to another cave fish, Chologaster, with eyes fully developed, it was urged that the argument in regard to cyclops fishes could have no weight. In response to this it was answered that possibly Chologaster had not been subjected to subterranean influences long enough to be affected, and this objection was anticipated by urging that we have no right to assume that Chologaster is a more recent inhabitant of the caves, until proven.

The discovery of another species of Chologaster, taken from a spring at the base of a limestone cliff in Illinois, has given Professor Forbes an opportunity to make careful comparisons with the cave Chologaster. He says in regard to it "The most important and

few families of fresh-water mollusks are intimately related to those forms which live in the sea between high- and low water mark, and those which can withstand the influence of brackish water. He cited certain families of fresh-water mollusks which are so closely related to tidal forms as hardly to be distinguished from them. . . . . In explaining the [illegible] of species of fresh-water mollusks in [illegible] parts as the very few forms in Europe, we might look to an explanation of the [illegible] in the past geological history of the two continents.

In Europe there have been no great inland seas, while in America its past history shows the enclosing of large tracts of water in which freshening from brackish water went on, and while many forms succumbed to these changed conditions, only those forms survived which resemble certain littoral species. And with the curious modifications that must have taken place in these changed conditions, one gets a possible explanation of the great variety of mollusks in our western rivers."

interesting peculiarity of this species indicates a more advanced stage of adaptation to a subterranean life than that of its congeners." Referring to Professor Putnam's arguments, Professor Forbes says that "the discovery of a species of Chologaster, which frequents external waters, of an immediate subterranean origin, supplies all needed proof that the genus either has a shorter subterranean history than Amblyopsis, or, at any rate, has remained less closely confined to subterranean situations; and that in either case the occurrence of eyes, partial absence of sensory papillæ and persistence in color, are thus accounted for consistently with the doctrine of 'descent with modification.'" In this connection it may be of interest to read the curious fact recorded by Mr. S. H. Trowbridge [67] of the discovery in the Missouri river of a shovel-nosed sturgeon which had the skin growing over the eyes, completely inclosing them. Dr. S. H. Scudder, [68] in a memoir read before the National Academy, brings forward evidence to show that ordinal features among insects were not differentiated in Palæozoic times, but that "all Palæozoic insects belonged to a single order which, enlarging its scope as outlined by Goldenberg, we may call Palæodictyoptera; in other words, the palæozoic insect was a generalized Hexapod, or more particularly a generalized Heterometabolon." In a memoir on the earliest winged insects of America embracing a reëxamination of "The Devonian Insects of New Brunswick" published by the author, Dr. Scudder replies to some sharp criticisms and objections made by Dr. Hagen and pertinently says, "That there is no evidence—but the contrary—that Dr. Hagen in his investigations uses the 'theory of descent' as a working hypothesis, without which no one studying any group of animals in the period of its rise and most rapid evolution can expect to do otherwise than stumble and wander astray. To refuse it is to merit failure."

Prof. J. S. Kingsley, [69] in his study of Limulus, regards it is an Arachnid, but states that its ancestors take us back to a time when the distinctions between the Crustacea and Arachnida were far less marked than now.

Dr. A. S. Packard,[70] in a paper on the "Genealogy of the Insects," shows by means of a "genealogical tree" the descent of the class from the Thysanura, with some hypothetical creature not unlike Scolopendrella, as the probable stem-form of the Hexapods. It is through the resemblance the larvæ of the different orders of in-

sects bear to various members of the Thysanura that this scheme is justified. It may not be out of place to say here that the use of the "genealogical tree," in suggesting the probable line of descent of various allied groups, has been severely condemned by some as leading to no practical good in classification. It seems to me, however, the only clear scheme for the proper working out of the ascertained or hypothetical relationships of animals; it is thought-exciting, its very attitude provokes studious inquiry and suggestive inferences. It may be called the modern tree of knowledge.

The modern genealogical tree as used by the biological student (and as well by the ethnologist, philologist and others) is a graphic diagram of the relationships between groups as understood by the projector, and, as such, is a most commendable and useful method with which to illustrate his meaning. With additional knowledge one can see, at a glance, the points that need strengthening, and he can pare, prune, or even graft new fruits on the old stock, or if it is rotten at the trunk, cut it down altogether. These trees have always been in vogue with the older naturalists, only, in the old style of arboriculture, the trunk was always kept stiffly vertical while the branches were bent down and trained horizontally, being firmly attached to the main stem by printers' devices of long and short brackets. In this attitude it reminded one of the dwarfed and deformed trees of the Chinese and very properly typified the dwarfed and deformed way of looking at classification.

Never was the provisional use of a genealogical tree more completely justified than in a memoir by Dr. Alexander Agassiz[1] on the "Connection between Crinoidea and Echinoid Types." He certainly speaks in no uncertain terms when in considering the Spatangoids of the chalk he says, "They lead as directly through the Palæostomidæ and the Collyritidæ to the Assulinidæ which have persisted to the present day," and other relationships of the same nature are repeatedly urged as would not only justify the use of the genealogical diagram against which he so strongly inveighed in his admirable address before this Association at the Boston meeting, but had he adopted this method a much clearer view of the very points he wished to emphasize would have been afforded his readers.

It was the strictures of Agassiz above referred to that led Prof. W. K. Brooks[2] to write a paper on the subject of "Speculative

Zoölogy" in which he most earnestly and ably defends the use of genealogical diagrams and justly says, "If phylogenetic speculations retard science, speculations upon homology must do the same thing, and the only way to avoid danger will be to stick to facts, and, stripping our science of all that renders it worthy of thinking men, to become mere observing machines."

Since 1876 Professor Marsh and Professor Cope have in various journals and Government publications presented the results of their discoveries of the past vertebrate life of North America. The General Government has published the two great monographs of Professor Marsh on the Dinocerata, an extinct order of gigantic mammals, and the Odontornithes, an order of extinct toothed birds, as well as Professor Cope's great volume on the Tertiary Vertebrata besides other memoirs by the same authors. Space will forbid more than a passing allusion to the varied and remarkable additions to our knowledge of extinct vertebrate life made by these naturalists.

Had a moiety of the work accomplished by these investigators been known to Geoffroy St. Hilaire the theory of descent would have been established long before Darwin, though to Darwin and Wallace belongs the full credit of defining the true cause. Leidy, Marsh and Cope have not only brought to light a great number of curious beasts, many of them of gigantic and unique proportions, but forms revealing in their structure the solution of many morphological puzzles and throwing light on the derivation of many obscure parts.

The discovery in the western tertiaries of multitudes of huge and monstrous mammals and, earlier still, of gigantic and equally monstrous reptiles, naturally led at once to an inquiry as to the cause of their extinction. "Nothing can be more astonishing," says Prof. Joseph LeConte,[73] "than the abundance, variety and prodigious size of Reptiles in America up to the very close of the Cretaceous, and the complete absence of all the grander and more characteristic forms in the lowest Tertiary; unless, indeed, it be the correlative fact of the complete absence of mammals in the Cretaceous and their appearance in great numbers and variety in the lowest Tertiary. . . . " The wave of reptilian evolution had just risen to its crest, and perhaps was ready to break, when it was met and overwhelmed by the rising wave of mammalian Evolution." In this paper of LeConte's, which is entitled "On

Critical Periods in the History of the Earth and their Relation to Evolution: and on the Quaternary as such a Period," may be found an excellent rejoinder of Prof. Clarence King's lecture before the Sheffield Scientific School on the subject of Catastrophism and Evolution.

Among the most interesting discoveries connected with these creatures is the determination by Professor Marsh[14] that these early mammals, birds and reptiles had brains of diminutive proportions. He says in regard to the order Dinocerata, a group of gigantic mammals whose remains have been found in the tertiary deposits of the Rocky Mountain region, that they are the most remarkable of the many remarkable forms brought to light. The brain of these creatures was remarkable for its diminutive proportion. So small indeed was the brain of *Dinoceras mirabile* that it could "apparently have been drawn through the neural canal of all the presacral vertebræ." In alluding to the successive disappearance of the large brutes, the cause is not difficult to find: "The small brain, highly specialized characters, and huge bulk, rendered them incapable of adapting themselves to new conditions, and a change of surroundings brought extinction. The existing Proboscidians must soon disappear, for similar reasons. Smaller mammals, with larger brains, and more plastic structure, readily adapt themselves to their environment, and survive, or even send off new and vigorous lines. The Dinocerata with their very diminutive brain, fixed characters, and massive frames, flourished as long as the conditions were especially favorable, but, with the first geological change, they perished, and left no descendants." Professor Marsh says that the brain of Dinoceras was in fact the most reptilian brain in any known mammal.

Professor Cope[15] in describing the brain of Coryphodon from the deposits of New Mexico, says: "The large size of the middle brain and olfactory lobes gives the brain as much the appearance of that of a lizard as of a mammal." This is one of the lowest mammalian brains known. There are others from the lower Eocene with equally low brains as Arctocyon of Gervais and Clinatherium of Marsh. Cope believes that the type of brain of these early creatures is so distinct as to necessitate the erection of a third subclass of equal rank with the groups Gyrencephala and Lyencephala which he would name as the Protencephala. He shows their approximation to reptiles.

Cope[76] refers to Gratiolet as showing that a great development of the olfactory is a character of an inferior type; in fact, the more we ascend into paleontological antiquity, the more we find that the olfactory lobes display a greater development in comparison with the cerebral hemispheres. Dr. B. G. Wilder[77] has shown that in the lamprey the only part which can be regarded as a cerebral hemisphere lies laterad of the olfactory lobe. In Dipnoi he finds that the cerebral outgrowth is ventrad. In another paper[78] he says: "In either of these directions in which what may be regarded as the special organ of the mind is projected among these low or generalized forms, there would seem to be mechanical obstacles to any considerable expansion; but dorsally there is opportunity for comparatively unlimited extension, and it is in this direction that the hemispheres begin to develop in the Amphibia and attain such enormous growth in Birds and Mammals." How far the small brain and presumably stolid intellects brought about the extinction of the huge tertiary mammals may be better understood by the suggestions offered by Prof. A. E. Verrill[79] in a lecture at Yale College entitled "Facts Illustrative of the Darwinian Theory." He shows what an important factor parental instinct is in the evolution of species. He regards the lack of parental care "as one of the probable causes, though usually overlooked, of the extinction of many of the large and powerful reptiles of the mesozoic age and of the large mammals of the tertiary." He says: "The very small size of the brain and its low organization in these early animals are now well known, and we are justified in believing that their intelligence or sagacity was correspondingly low. They were doubtless stupid and sluggish in their habits, but probably had great powers of active and passive resistance against correspondingly stupid carnivorous species. But unless the helpless young were protected by their parents, they would quickly have been destroyed; and such species might, in this way, have been rapidly exterminated whenever they came in contact with new forms of carnivorous animals, having the instinct to destroy the new-born young of mammals, and the eggs and young of oviparous reptiles. Thus it would have come about, that the more intelligent forms, by the development of the parental instinct for the active protection of their young against their enemies, would have survived longest, and therefore would have transmitted this instinct, with other correlated cerebral developments, to their descendants."

Prof. John Fiske, in his Cosmic Philosophy, arrived at a similar conclusion in regard to early man. He showed that when variations in intelligence became more important than variations in physical structure, then they were seized upon to the relative exclusion of the latter.

The derivative theory has not only clearly revealed the fact that animals have been derived from preëxisting forms, but it shows even more clearly that organs have been evolved as well. It is difficult in a general review of this nature to separate clearly the two classes of facts.

Professor Cope[48] has traced the genesis of the quadritubercular tooth in the mammals of the present day. He finds that the type of the superior molar tooth of the mammals of the Puerco epoch was triangular or tritubercular, that is, with two external and one internal tubercle. Of forty-one species of mammals of this epoch all but four of them had this type of tooth. He finds that this tooth exists to-day only in the insectivorous and carnivorous marsupials. In brief he shows a gradual change taking place from the early primitive type of tooth in the gradual development of another tubercle. The same author,[49] in defining the characters of an ancient order of mammals, the Amblypoda, says they are the most generalized order of hoofed mammals, being intermediate in the structure of their limbs and feet between the Proboscidia, the Perissodactyla and Artiodactyla, which fact together with the small size of the brain places them in antecedent relation to the latter, in a systematic sense, connecting them with the lower mammals with small and smooth brains still in existence; and in a phylogenetic sense since they precede the other orders in time, they stand in the relation of ancestors.

Professor Cope,[50] in a paper read before this Association on the "Classification of the Ungulata," gives special attention to the arrangement and character of the carpal and tarsal bones. He shows "that the weaker structure of the carpus and tarsus appears first in time; that the stronger structure appeared first in the posterior limbs, and that the interlocking structure has greatly multiplied, while the linear has dwindled and mostly disappeared. Here is a direct connection between mechanical excellence and survival."

In the light of Mr. Caldwell's unquestionable determination of the oviparous character of that curious mammal, the duck-bill

mole, associated with its known reptilian bearings as deduced from its skeleton and other features, the deductions of Professor Cope [83] regarding the "Relations between the Theromorphous Reptiles and the Monotreme Mammalia" are of great interest.

In the Theromorpha are two divisions, one of which, the Pelycosauria, is limited to the Permian, and of one of this group he makes the following comparisons: "1. The relations and number of the bones of the posterior foot are those of the Mammalia much more than those of the Reptilia. 2. The relations of the astragalus and calcaneum to each other are as in the Monotreme *Platypus anatinus*. 3. The articulation of the fibula with both calcaneum and astragalus is as in the Monotreme order of mammals."

In brief he shows the affinity of this reptile to be with the monotremes, and that the affinities are very important in the light of Mr. Caldwell's researches, and the further fact that the development of the egg is meroblastic confirms, so to speak, the reptilian affinities of the monotremes.

Here then are a series of observations by different observers from different standpoints, all telling the same story. Osteologists have long ago pointed out the reptilian affinities of the monotremes from the character of the skeleton. The anatomists in like manner have insisted upon certain reptilian characters as well as avian characters from its internal structure. A trained zoölogist now studies it on the ground and finds it laying true eggs, a fact that had been insisted upon several times in the present century. More significant still, the study of these eggs shows that they go through a reptilian mode of development. And now the paleontologist brings to light the remains of a reptile from the Permian rocks and again establishes the same relations.

In this connection the examination by Dr. Henry C. Chapman [84] of a fœtal kangaroo and its membranes is of interest. The fœtus he examined was fourteen days old. He states that it had no true placenta and says "If the parts in question have been truthfully described and correctly interpreted, as partly bridging over the gap between the placental and non-placental vertebrates, they supply exactly what the theory of evolution demands and furnish, therefore, one more proof of the truth of that doctrine."

To those who have already been startled by the memoir of Dr. W. Baldwin Spencer on the presence and structure of the pineal gland in Lacertilia and the evidence that it represents a third eye

in a rudimentary condition, it will be interesting to know that among some of the earlier mammals the pineal gland may have assumed functional importance as an eye. Prof. Henry F. Osborn[26] shows that in the skull of the curious mammal Tritylodon, of Owen, there is seen a parietal foramen in exactly the same position and relation as in the lizard Sphenodon.

Professor Osborn regards this fact of remarkable interest, as it adds greatly to the rapidly accumulating evidence for the reptilian affinities of the mammalia. Professor Owen, in the description of this unaccountable opening, suggested that it might be due to posthumous injury.

Professor Marsh,[27] in a description of the skull of Diplodocus, a Dinosaur, describes a fontanelle in the parietal on the median line directly over the cerebral cavity. He adds, however, that this may be merely an individual variation.

Professor Cope[28] observes an enormous fronto-parietal foramen in the skull of *Empedocles molaris*, a curious creature from the Permian.

It would appear evident from these facts that at one time the pineal gland, which in the mammals is in a rudimentary condition and in certain Lacertilia sufficiently perfect, as an eye, to be sensitive to light impressions at least, was, in certain extinct mammals and reptiles, of large size and functionally active. It is a significant fact that no sooner does some one opposed to evolution undertake to lay down the law by setting a boundary to type features, than a discovery is made that breaks down the barrier. Thus Dr. Thomas Dwight,[29] in an interesting memoir on the "Significance of Bone Structure" in which he makes a brave defence for teleology, says, in speaking of the persistence of the vertebrate plan, "There are never, for instance, more than two eyes or one mouth or two pairs of limbs," and, lo! an extra eye is immediately added.

Dr. Spencer Trotter[30] has made a study of the collar bone and its significance, in which he accounts for its presence or absence in mammalia by correlating it with the life habits of the animal in the use of the fore limb. He says "Every fully developed tissue in an organism is needed or it would not be there; and just so soon as by increasing change in life and habits it becomes a factor of less and less importance to the animal, it fails more and more to attain its former standard of development, and in time

falls back to the primitive condition from which it arose and finally disappears."

Many new and interesting facts have been added sustaining the affinity between the birds and reptiles. Prof. O. C. Marsh [90] made a careful study of the Archeopteryx in the British Museum. The new points he has added bring out still more strongly the extraordinary characters blended in this creature. Among other features he discovered the separate condition of the pelvic bones, and shows that while it must be considered a bird, yet it has true teeth, bi-concave vertebræ, three separate fingers in each hand, all furnished with claws, metatarsals and metacarpals, equally unanchylosed and the pelvic bones separate, as already mentioned.

Dr. J. Amory Jeffries,[91] in a study of the claws and spurs on birds' wings, has presented an interesting table showing the number of phalanges in each finger, from the highest to the lowest family of birds, with the presence or absence of claws recorded for each finger. This table shows very clearly that the higher birds have fewer phalanges and no claws, and as one approaches the lower families the phalanges increase in number, the first finger having two phalanges and the second and third fingers being tipped with claws.

In a brief study of the tarsus of low aquatic birds,[92] made with special reference to the interpretation of the ascending process of the astragalus with the intermedium of reptiles, I observed a separate centre of ossification for this so-called process, observed its unquestionable position between the tibiale and fibulare, its increase in size with the growth of the bird and its final anchylosis with the proximal tarsal bones. In the bones of a young Dinornis, which through the courtesy of Dr. Henry Woodward I was kindly permitted to examine in the British Museum, the ascending process was large and conspicuous and firmly anchylosed with the coossified tarsals to the distal end of the tibia. Professor Marsh,[93] in a study of the metatarsal bones of Ceratosaurus, a Dinosaur discovered by him, found that the metatarsals coössified in the same manner as those of the Penguin.

The question as to the existence of a sternum in Dinosaurian reptiles has long been in doubt. Professor Marsh [94] has, however, discovered in Brontosaurus, one of the largest known Dinosaurs, two flat bones which he regards as clearly belonging to the sternum. They correspond to the immature stage of similar parts in birds.

Dr. Alexander Agassiz,[94] in a study of the young stages of certain osseous fishes, shows that while the tail is a modified intercostal one, it is for all that in complete accordance with embryonic growth and paleontological development; and, independently, Dr. John A. Ryder[95] finds that "the median fins of fishes normally present five well-marked conditions of structure which correspond inexactly to as many stages of development, which, in typical fishes, succeed each other in the order of time."

Mr. James K. Thatcher,[96] in a study of the "Median and Paired Fins, a contribution to the history of vertebrate limbs" shows "that the limbs with their girdles were derived from a series of similar simple parallel rays, and that they were a specialization of the continuous lateral folds or fins evidenced in embryos, which were with some probability homologous with the lateral folds or metapleura of the adult Amphioxus."

A great amount of work has been done in making clear the earlier stages in the development of animals and breaking down the hard and fast lines which were formerly supposed to exist between the larger divisions. Dr. C. S. Minot,[97] in a series of papers on Comparative Embryology, in referring to the work accomplished says "These researches have completely altered the whole science of comparative anatomy and animal morphology by entirely upsetting a large part of Cuvier's classification and the idea of types upon which it was based, substituting the demonstration of the fundamental identity of plan and structure throughout the animal kingdom from the sponges to man."

Prof. C. O. Whitman,[98] in describing a "rare form of the blastoderm of the shark, in which the primitive groove extended to the very margin of the blastoderm, terminating here in the marginal notch first observed by Balfour," justly contends that "in the origin of the embryo from a germ-ring by the coalescence of the two halves along the axial lines of the future animal, and, secondly, in the metameric division which follows in the wake of the concrescence," we have evidence of the annelidan origin of the vertebrates since concrescence of the germ bands is a well established fact for both chætopods and leeches.

The tracing of apparently widely divergent structures to a common origin has engaged the attention of many of our investigators. Not only has a large amount of evidence been offered to show a common origin of widely separated structures, but mention of a

speculative and theoretical character have given us a possible clew to the avenues we may follow in further establishing a proof of the unity of origin of forms and parts.

Dr. Francis Dercum [99] gives an interesting review of the structure of the sensory organs and urges that the evidence goes to prove the common genesis of these organs.

Prof. A. Hyatt [100] has presented an interesting study of the larval history of the origin of tissue. He attempts to show a phyletic connection between the Protozoa and Metazoa, and also to show that the tissue cells of the latter are similar to asexual larvæ "and are related by their modes of development to the Protozoa just as larval forms among the Metazoa themselves are related to the ancestral adults of the different groups to which they belong." Dr. John A. Ryder [101] has studied the law of nuclear displacement and its significance in embryology. In a discussion of this subject he says "The mode of evolution of the yelk is of great interest, and doubtless occurred through the working of natural selection. It is evidently adaptive in character, and the necessity for its presence as an appendage of the egg grew out of the exigencies of the struggle for existence."

Mr. H. W. Conn, [102] in a paper entitled "Evolution of the Decapod Zoæ" gives a number of striking and suggestive facts explaining the reason of the multiform and diverse character of the larvæ of decapod crustaceans. He shows in what way natural selection has affected the young. What has seemed an almost insoluble mystery, as to why the early stages of closely allied crustaceans should be so often diverse in their varied armature of long spines, their powers of rapid flight, etc., are explained on the ground of natural selection. In another memoir by the same author,[103] on the significance of the "Larval skin of Decapods," a very complete discussion of the views of authors are given. At the outset he shows that the crustaceans are a particularly favorable group for the study of phylogeny and then suggests the character of the ancestral form of the Crustacea from the significance of the larval envelope. The author infers from his studies that "all Decapods are to be referred back to a form similar to the Protozoæ (Zoæ) in which the segments of the thorax and probably of the abdomen were present, and whose antennæ were locomotive organs."

Not the slightest justice can be done this admirable discussion in the brief reference here made, but the perusal of it will certainly

impress one with the profound change which has taken place in the method of treating a subject of this nature compared to the treatment it might have received in pre-Darwinian days. Indeed the features discussed in this paper would not have attracted a moment's attention from the older naturalists.

Since Darwin published his provisional theory of Pangenesis it has provoked speculative efforts on the part of some of our naturalists to devise other hypotheses which might answer some of the objections urged against Darwin's hypothesis. Space will permit only a mention of a few of these papers. Prof. W. K. Brooks[34] presented, in brief abstract at the Buffalo meeting eleven years ago, a provisional theory of Pangenesis. These views more elaborated are now published in book form under the title of "The Laws of Heredity." An illustrious reviewer says it is the most important contribution on the speculative side of Darwinism that has ever appeared in this country. He has also aptly termed studies of this nature molecular biology. Dr. Louis Elsberg at the same meeting also read a paper on the plastidule hypothesis.

Dr. John A. Ryder[35] has made an interesting contribution entitled "The Gonomute versus the Plastidule as the Ultimate Physical Unit of Living Matter." In this paper he discusses Darwin's provisional theory of Pangenesis and shows it to be untenable from Galton's experiments.

Haeckel's provisional hypothesis of the Perigenesis of the Plastidule is clearly stated, and he closes by saying that the logical consequences of the acceptance of Haeckel's theory and with it the theory of dynamical differentiation—because the latter is no longer an hypothesis—forever relegate teleological doctrines to the category of extinct ideas.

The widespread public interest in Darwinism arose from the fact that every theory and every fact advanced in proof of the derivative origin of species applied with equal force to the origin of man as one of the species. The public interest has been continually excited by the consistent energy with which the church, Catholic and Protestant alike, has inveighed against the dangerous teachings of Darwin. Judging by centuries of experience, as attested by unimpeachable historical records, it is safe enough for an intelligent man, even if he knows nothing about the facts, to accept promptly as truth any generalization of science which the church declares to be false, and conversely to repudiate with equal

promptness, as false, any interpretation of the behavior of the universe which the church adjudges to be true. In proof of this sweeping statement one has only to read the imposing collection of facts brought together by Dr. White, the distinguished ex-president of Cornell University, which are embodied in his work entitled "The Warfare of Science," as well as two additional chapters on the same subject which have lately appeared in the Popular Science Monthly. One then realizes the lamentable but startling truth that, without a single exception, every theory or hypothesis, every discovery or generalization of science has been bitterly opposed by the church, and particularly by the Catholic church which resists, and, as Huxley says, "must, as a matter of life and death, resist the progress of science and modern civilization."

Only the briefest reference can here be made to a few of the numerous contributions on the subject of man's relationship to the animals below him. The rapidly accumulating proofs of the close relation existing between man and the Quadrumana make interesting every fact, however trivial, in regard to the structure and habits of the higher apes.

Dr. Arthur E. Brown [106] has made some interesting experiments with the monkeys at the zoölogical gardens in Philadelphia. He found that the monkeys showed great fear, as well as curiosity, when a snake was placed in their cage, though they were not affected by other animals, such as an alligator and turtle. On the other hand, mammals belonging to other orders showed no fear or curiosity at a snake. These experiments, repeated in various ways, lead him to only one logical conclusion "that the fear of the serpent became instinctive in some far distant progenitor of man, by reason of his long exposure to danger and death in a horrible form, from the bite, and that it has been handed down through the diverging lines of descent which find their expression to-day in Homo and Pithecus."

The same author,[107] in an exceedingly interesting description of the higher apes, says "Mr. A. R. Wallace once called attention to the similarity in color existing between the orang and chimpanzee and the human natives of their respective countries. It would, indeed, seem as if but half the truth had been told, and that the comparison might be carried also into the region of mind; the quick, vivacious chimpanzee partaking of the mercurial disposi-

tion of negro races, while the apathetic slow orang would pass for a disciple of the sullen fatalism of the Malay."

Doctor Brown[108] has also given a description of the grief manifested by a chimpanzee on the death of its mate. His grief was shown by tearing his hair or unfolding at the short hair on his head. The yell of rage was followed by a cry the keeper had never heard before, a sound which might be represented by bah-ah-ah-ah uttered somewhat under the breath, and with a plaintive sound like a moan.

Mr. W. F. Hornaday[109] read at the Saratoga meeting of this Association an exceedingly interesting paper on the "Habits of the Orang" as observed by him in its native forests. He says "Each individual of the Borneo orangs differs from his fellows and has as many facial peculiarities belonging to himself alone as can be found in the individuals of any unmixed race of human beings." After recounting the many traits of the orang, heretofore regarded as peculiar to man, he says, "let any one who is prejudiced against Darwinian views, go to the forests of Borneo. Let him there watch from day to day this strangely human form in all its various phases of existence. Let him see it climb, walk, build its nest, eat and drink and fight like human 'roughs.' Let him see the female suckle her young and carry it astride her hip precisely as do the Coolie women of Hindostan. Let him witness their human-like emotions of affection, satisfaction, pain and childish rage — let him see all this and then he may feel how much more potent has been the lesson than all he has read in pages of abstract ratiocination."

Prof. W. S. Barnard several years ago in a study of the myology of man and apes, showed that the sphincter muscle which Trail studied in the higher apes and which he supposed had no homologue in man was really homologous with the *Gluteus minimus* in man. Dr. Henry C. Chapman,[110] in a study of the structure of the orang outang, has confirmed the truth of Barnard's discovery. Doctor Chapman is led to infer that the ancestral form of man was intermediate in character, as compared with living anthropoids or lower monkeys, agreeing with them in some respects and differing from them in others.

The osteological affinities which man has with the Lemuroidæ, as insisted upon by Mivart, are also recognized by Cope.[111] In a general paper on the "Origin of Man and Other Vertebrates"

he says "An especial point of interest in the phylogeny of man has been brought to light in our North American beds. There are some things in the structure of man and his nearest relatives, the chimpanzee, orang, etc., that lead us to suspect that they had rather come from some extinct type of lemurs."

It would seem as if we must look farther back than the higher apes for the converging lines of man's relations with them. The earliest remains of man or the apes found fossil, presenting as they do marked types with little tendency to approach each other, would in themselves suggest an earlier origin for both stocks.

In a paper by Professor Cope[112] on "Lemurine Reversion in Human Dentition" he says, in concluding his article: "It may be stated that the tritubercular superior molars of man constitute a reversion to the dentition of the Lemuridæ of the Eocene Period of the family Anaptomorphidæ, and second, that this reversion is principally seen among Esquimaux and the Slavic, French and American branches of the European race."

In another paper by the same author[113] on the "Developmental Significance of Human Physiognomy," he compares the proportions of the body and the facial peculiarities of man with the higher apes and human infants and shows that the Indo-European, on the whole, stands higher than the other races in the acceleration of those parts by which the body is maintained in an erect position, and in the want of prominence of the jaws and cheek bones, which are associated with a greater predominance of the cerebral part of the skull and consequently greater intellectual power.

Dr. Harrison Allen,[114] in a study of the shape of the hind limb as modified by the weight of the trunk, dwells on the manner of articulation in the gorilla of the fibula with both calcaneum and the astragalus, as well as the fact that the astragalus in that genus possessed a broad deflected fibula facet and says "This peculiar projection is rudimental in the astragalus of civilized man, but was found highly developed in an astragalus from an Indian grave found at Cooper's point, New Jersey."

In my Buffalo address, I alluded to a paper by Prof. N. S. Shaler on the intense selective action which must have taken place in the shape and character of the pelvis in man on his assumption of the erect posture—the caudal vertebræ turning inward, the lower portion of the pelvis drawing together to hold the viscera, which had before rested on the elastic abdominal walls, the attending difficulty of

parturition, etc. Dr. S. V. Clevenger [15] has since called attention to other inconveniences resulting from man's escape from his quadrumanous ancestors. In a paper entitled "Disadvantages of the Upright Position," he dwells particularly on the valves in the veins to assist the return of blood to the heart which considered from the usual teleological point of view seems right enough; but why, he asks, should man have valves in the intercostal veins? He shows that in a recumbent position these valves are an actual detriment to the flow of blood: "An apparent anomaly exists in the absence of valves from parts where they are most needed, such as the vena cavæ, spinal, iliac, hæmorrhoidal and portal. The azygos veins have imperfect valves. Place man upon 'all fours' and the law governing the presence and absence of valves is at once apparent, applicable, so far as I have been able to ascertain, to all quadrupedal and quadrumanous animals. Dorsad veins are valved; cephalad, ventrad and caudad veins have no valves." By means of two simple diagrams he shows clearly the distribution of valved and unvalved veins as they exist in mammals, and why in man the same arrangement becomes detrimental. He dwells on the number of lives that are sacrificed every year by the absence of valves in the hæmorrhoidal veins. He also mentions other disadvantages in the upright attitude, as seen in the position of the femoral artery, even with man's ability to protect it. Its exposed condition is a dangerous element. Inguinal hernia of rare occurrence in mammals occurs very often in man; at least twenty per cent being affected. Strangulated hernia also causes many deaths. Prolapsus ani and other troubles and diseases are referred to by Doctor Clevenger as due to the upright position. In other words the penalties of original sin are in fact the penalties resulting from man's assumption of the erect posture.

In another paper by the same author,[16] on the "Origin and Descent of the Human Brain," he gives an interesting sketch of the phylogenesis of the spinal cord to its ultimate culmination in the development of the brain of man. He says that the most general interest centres in the large mass of cells and nerve fibres called the cerebrum. "In the Ornithorhynchus, it is smooth and simple in form, but the beaver also has an unconvoluted brain which shows at once the fully of attaching psychological importance to the number and intricacy of folds in animal brains. With phrenology, which finds illustrations in the material process of the

temporal bone and amativeness in the occipital ridge, the convolutional controversies must die out, as has the so-called science of palmistry, which reads one's fate and fortune in the skin-folds of the hand."

Prof. Alexander Graham Bell [117] has presented a memoir to the National Academy on the "Formation of a Deaf Variety of the Human Race" in which he shows by tables a series of generations of certain families in which the progenitors being deaf mutes this peculiarity becomes perpetuated in many of the descendants. Recognizing fully the laws of heredity, natural selection, etc., he shows that the establishment of deaf-mute schools, in which a visual language is taught which the pupils alone understand tends to bring them into close association with each other; and, that naturally with this seclusion, acquaintance ripens into friendship and love and that statistics show that there is now in process of being built up a deaf variety of man.

Dr. W. K. Brooks,[118] animated by the cogency of Professor Bell's reasoning, is led to prepare an article entitled "Can Man be Modified by Selection?" In this paper he discusses the startling proposition of Professor Bell and recognizes the convincing proof which he furnishes to show that the law of selection does place within our reach a powerful influence for the improvement of our race. The striking character of the tables of facts presented by Professor Bell and the significant suggestions of Doctor Brooks lead one to consider how far the influence of selection has had to do with the character of great communities, as to their intelligence or ignorance. When we see nations of the same great race stock, one showing a high percentage of illiterates, a high death rate, degradation and ignorance, while just across the borders another nation, apparently no better off so far as physical environments are concerned, with percentage of illiterates and death rate low, intelligent and cleanly, we are led to inquire if here a strict scientific scrutiny with careful historical investigation will not reveal the cause of these conditions. Can it be proved beyond question that the illiteracy and degradation of Italy and Spain up to within recent years, at least, are the result of centuries of church oppression and the Inquisition, destroying at once, or driving out of the land all independent thinkers and at the same time forcing her priests to lead celibate lives and inducing others of cultivated and gentle minds to lead cloister lives? Is it also a fact, as Alphonse

de Candolle asserts, that by far the greater number of distinguished scientists have come from Protestant pastors? He gives a significant list of eminent men whose fathers were Protestant pastors saying that had they been priests of another religion forbidding celibate lives these men would not have been born.

It is considered an intrusion into matters which do not concern science when such inquiries are made, but the scientist has very deeply at heart the intellectual and moral welfare of the community. If the cause of degradation and ignorance, of poverty, of contagious disease, or of any of the miseries which make a nation wretched can be pointed out by scientific methods, then it is the stern duty of science to step in and at least show the reasons, even if the remedy is not at once forthcoming. The men who would be reformers and agitators and who by their earnestness and devotion get the attention of multitudes are unfit for their work if they show their ignorance, as most of them do, of the doctrines of natural selection and derivation.

Dr. C. S. Minot [18] read a paper before the Cincinnati meeting of this Association suggesting a rather startling proposition as to whether man is the highest animal, which led Dr. W. N. Lockington [19] to reply in a very able article entitled "Man's Place in Nature."

The great problem of food supply has led to legislative enactments for the purposes of regulating the trapping and netting of game and fish. State and government grants have been made for fish commissions; but unless the public are clearly educated in the rudiments of zoological science and the principles of natural selection, appropriations will come tardily and in limited amounts. Dr. W. K. Brooks, [20] in his report to the State of Maryland as one of the oyster commissioners, after showing the absurd way in which the problem of oyster protection has been dealt with and strenuously urging the necessity of oyster culture, calls attention to the fact that "civilized races have long recognized the fact that the true remedy is not to limit the demand, but rather to increase the supply of food, by rearing domestic sheep and cattle and poultry in place of wild deer and buffaloes and turkeys, and by cultivating the ground instead of searching for the natural fruits and seeds of the forests and swamps."

Mr. Ernest Ingersoll,[21] author of the "Report on the Oyster Industry," 10th U. S. Census, has, in an address before the Geo-

graphical Society of New York, a striking sketch of the effect of the white man on the wild animals of North America, showing that had the Indians remained in possession, little, if any, change would have taken place. The Indian, like the predaceous animals, hunts only for food and shows even in this habit, a wholesome self-restraint, never killing wantonly. He called attention to the survival of a number of small birds about the dwellings of man as the result of favorable conditions, such as a constant supply of food, etc. He shows that the contact of man in the main has been disastrous. His remarks on the oyster are timely; he shows its extermination along the coast by man's agency. "Hardly more than a century has elapsed since men believed that the oyster beds of New York were inexhaustible and that a small measure of legal protection, feebly maintained, was quite enough to sustain them against any chance of decay. So they thought in Massachusetts, where the oysters have not only disappeared but have been forgotten. So they think now in Maryland and Virginia, where their fond expectations are destined to equal downfall."

Prof. William H. Brewer,[123] in a paper on the "Evolution of the American Trotting-Horse," shows that the trotter is an American product and that it is still in process of evolution. He gives a column of figures to show the speed that has been attained in this new form of motion, from a speed of three minutes in 1818 down to two, ten and a quarter minutes in 1881. The materials for a curve is offered to mathematicians, and Prof. Francis E. Nipher,[124] in a mathematical article on the subject, shows that a definite time of ninety-one seconds will ultimately be attained by the American trotter. Mr. W. H. Pickering,[125] however, urges some objections to the deductions of Professor Nipher.

In drawing to a close this very imperfect summary of what American zoölogists have accomplished for evolution many other distinguished contributors might have been mentioned. The work of eminent physiologists and paleontologists has hardly been considered, nor has the long array of botanical facts for Darwin as revealed in the fascinating study of the relations which exist between flowering plants and insects, contrivances for cross fertilization, means of plant dispersion, etc., and the distinguished botanists connected with this work, received attention here. Indeed the proper limits for an address of this nature have been far exceeded.

Suffice it to say that all these students have worked from the standpoint of Derivative doctrines. A still greater triumph to Darwinists are the evidences of gradual conversion still going on among a few isolated workers who still remain stubborn, yet yielding to the pressure of these views by admitting features that ten years ago they repudiated.

There are two points to be emphasized here in closing, and one is that American biological science stands as a unit for evolution, and the other is, the establishment of a great generalization which shows that when intelligence became a factor in animals it was seized upon to the relative exclusion of other characteristics. This generalization offers an unassailable argument to-day for a wider, broader and deeper education for the masses. The untold misery and suffering of the working classes as witnessed in their struggles of the last two years would have been avoided had the rudiments of social science — even a knowledge of the value and significance of simple statistics, been appreciated by them.

The startling paper of Dr. Seaman [9] on the "Social Waste of a great City" shows the blundering, criminal way in which municipalities are controlled by coteries ignorant alike of Science and the beneficent mission she stands waiting to enter upon.

[Within ten years a number of general works on Evolution have appeared, the most important of which have been the "Law of Heredity" by Dr. W. K. Brooks, to which allusion has already been made, and the "Origin of the Fittest" by Prof. E. D. Cope, in which are brought together the various papers, memoirs, addresses, etc., of the author which have appeared from time to time in scientific journals and magazines. Nearly all the addresses read, within the past ten years, before this association by the presiding officers who were zoologists have been imbued with Darwinism and Derivation. The titles of the general articles which have appeared on evolution would fill a large catalogue.

The general addresses on the subject are legion. Indeed, as the revered botanist Asa Gray has well remarked, "Dante literature and Shakespeare literature have been the growth of centuries but Darwinism filled teeming catalogues during the life-time of the author."

While no reference can be made to these various publications, allusions must be made to the Darwin Memorial meeting of the Biological Society of Washington as containing a most appreciative résumé of the labors of the great naturalist. A perusal of the addresses on that occasion brings to mind very vividly the comprehensive range of the work of this great man. The Introductory by Prof. Theodore Gill is a strong sketch of the

wonderful revolution wrought in the methods and convictions of naturalists by the doctrines of Darwin. Of great interest and value also are the succeeding addresses read at that meeting, which were a "Biographical Sketch" by Dr. William H. Dall, "The Philosophic Bearings of Darwinism" by Major John W. Powell, "Darwin's Coral Island Studies" by Mr. Richard Rathbun, "Darwin's Investigations on the Relation of Plants and Insects" by Prof. Charles V. Riley, "Darwin as a Botanist" by Mr. Lester F. Ward, "Darwin on Emotional Expression" by Mr. Frank Baker, closing with "A Darwinian Bibliography" by Mr. Frederick W. True.

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125. Am. Jour. Sci. and Arts, Vol. xxvi, p. 378.
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